

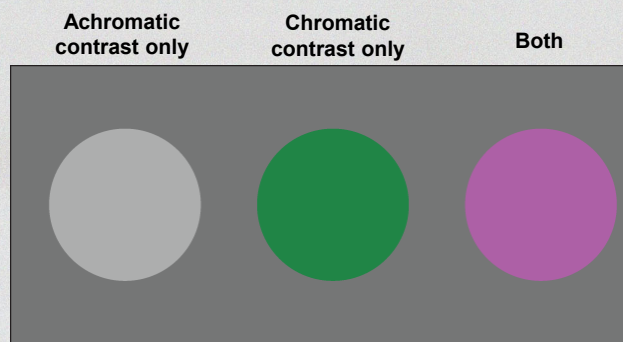


## Key elements of a good experimental design

- **Replication:**
  - Estimation of errors
  - Increase in precision
  - Larger range of observations (i.e. larger sphere of inference)
- **Randomization:**
  - Assigning treatments to experimental units at random
  - Appropriate sampling of experimental data
  - Avoiding bias and other sources of variation that cannot be controlled
  - Basis for any valid statistical test
- **An adequate control:**
  - Placebo, sham injections, etc
  - The main purpose of a control is to isolate the independent variable from other associated effects.

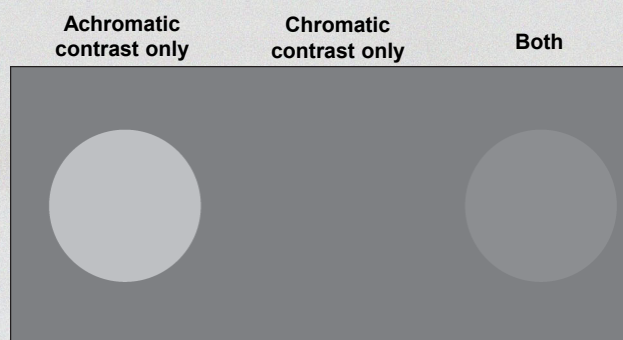
Testing for colour vision is all about controlling intensity!

Three objects on a grey background, all clearly visible:



## Achromatic and chromatic contrast

Viewed through brightness (luminance) channel only. In other words, viewed by a colour blind system



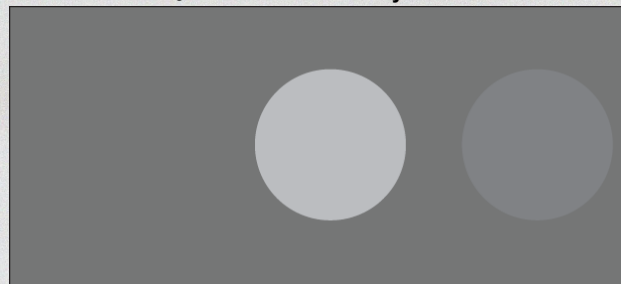
## Achromatic and chromatic contrast

Viewed through spectral (colour) channel only

**Achromatic  
contrast only**

**Chromatic  
contrast only**

**Both**



## Testing for colour vision

The two most basic questions are:

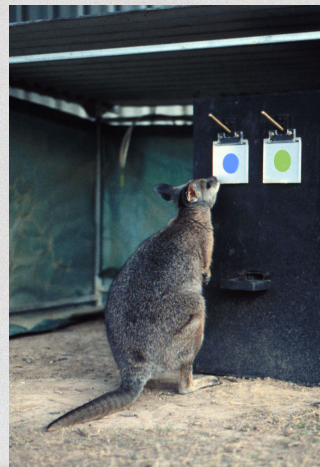
- Does an animal have colour vision?
- How many colour channels does the animal have? i.e. how many photoreceptor classes underlie the animal's colour vision?

Monochromacy? (colour blind)

Dichromacy? (e.g. dogs/cats)

Trichromacy? (e.g. humans)

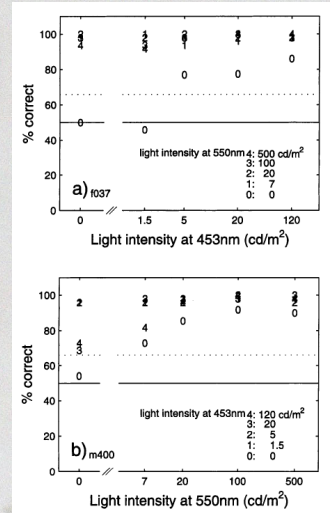
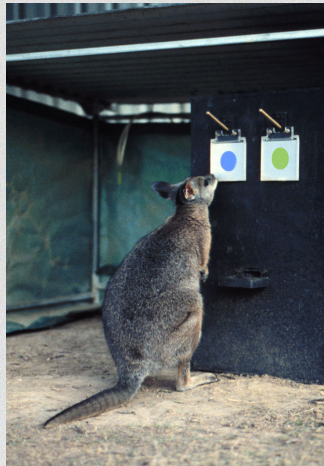
Tetrachromacy? (e.g. many birds and reptiles)



Hemmi 1999 JCPA

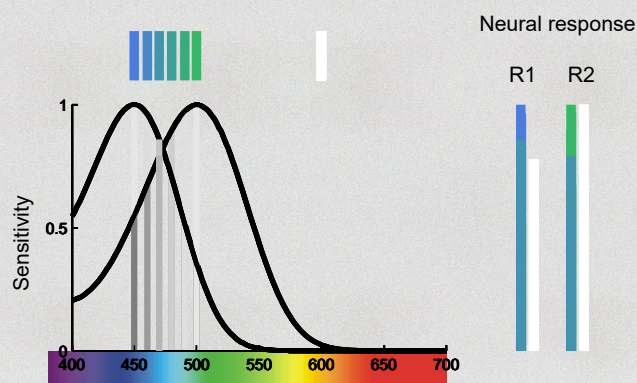
## Testing for colour vision

Dual forced choice discrimination task between two coloured lights of varying intensities



Hemmi 1999 JCPA

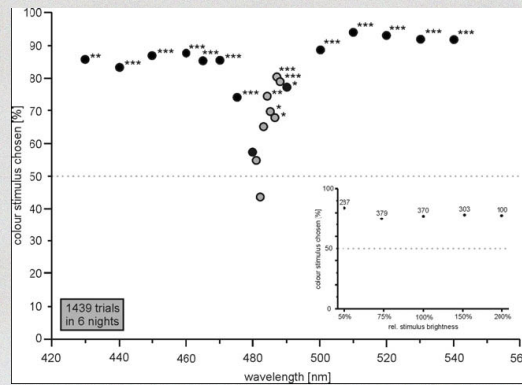
## Evidence for dichromacy: Neutral - point



To prove that an animal is dichromatic, one needs to show that their spectral sensitivity has a neutral- (or null-) point. This is the point along the wavelength spectrum where a dichromat cannot distinguish a single monochromatic colour from a broadband light (usually white). Trichromats do not have such a point.

## Evidence for dichromacy: Neutral – point in wallabies

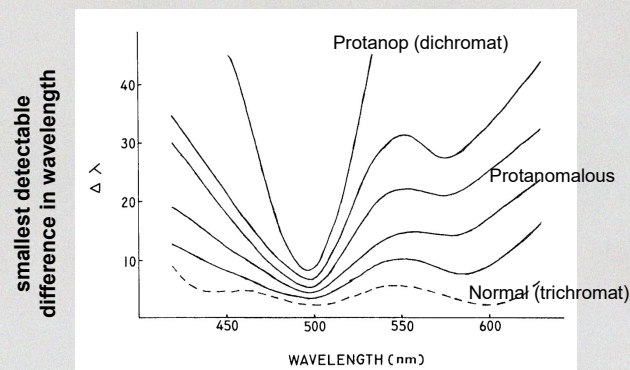
A absolute wavelength discrimination task



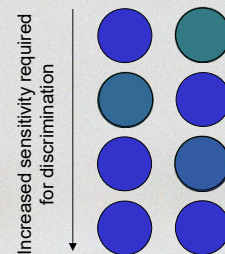
Ebeling & Hemmi 2014

## Colour threshold measurements: Wavelength discrimination: ability to distinguish two close monochromatic lights

Humans



Test stimuli



Jacobs 1981 Comparative color vision

## The main concepts

- Behavioural colour vision experiments are all about luminance!  
To show colour vision, one needs to eliminate brightness contrast.
- The null-point or neutral-point experiment is a conclusive way to show that an animal is a dichromat.
- Colour threshold experiments and colour mixing experiments (of which the null-point experiment is a special case), can be used to infer some of the underlying colour vision mechanisms e.g. the dimensionality of an animal's colour space.
- Don't forget the control!

